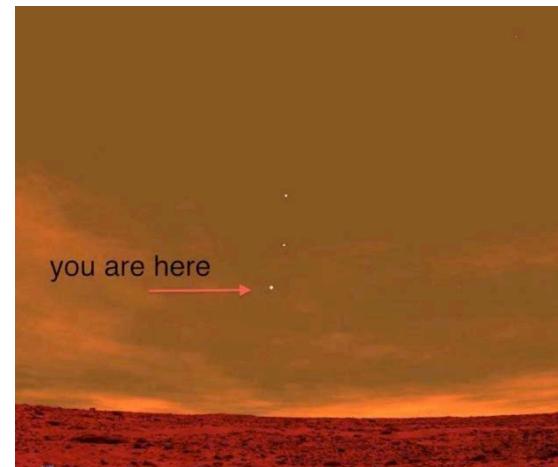


Human Factors Engineering and Ergonomics in Systems Engineering



Mihriban Whitmore, Ph.D.
NASA Johnson Space Center
September, 2017

Human Factors is...

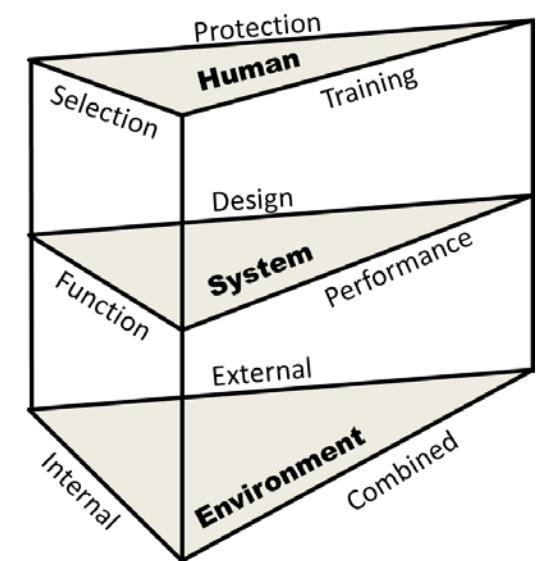
The study, discovery, and application of information about human abilities, human limitations, and other human characteristics to the design of tools, devices, machines, systems, job tasks and environments for effective human performance.

-Alphonse Chapanis

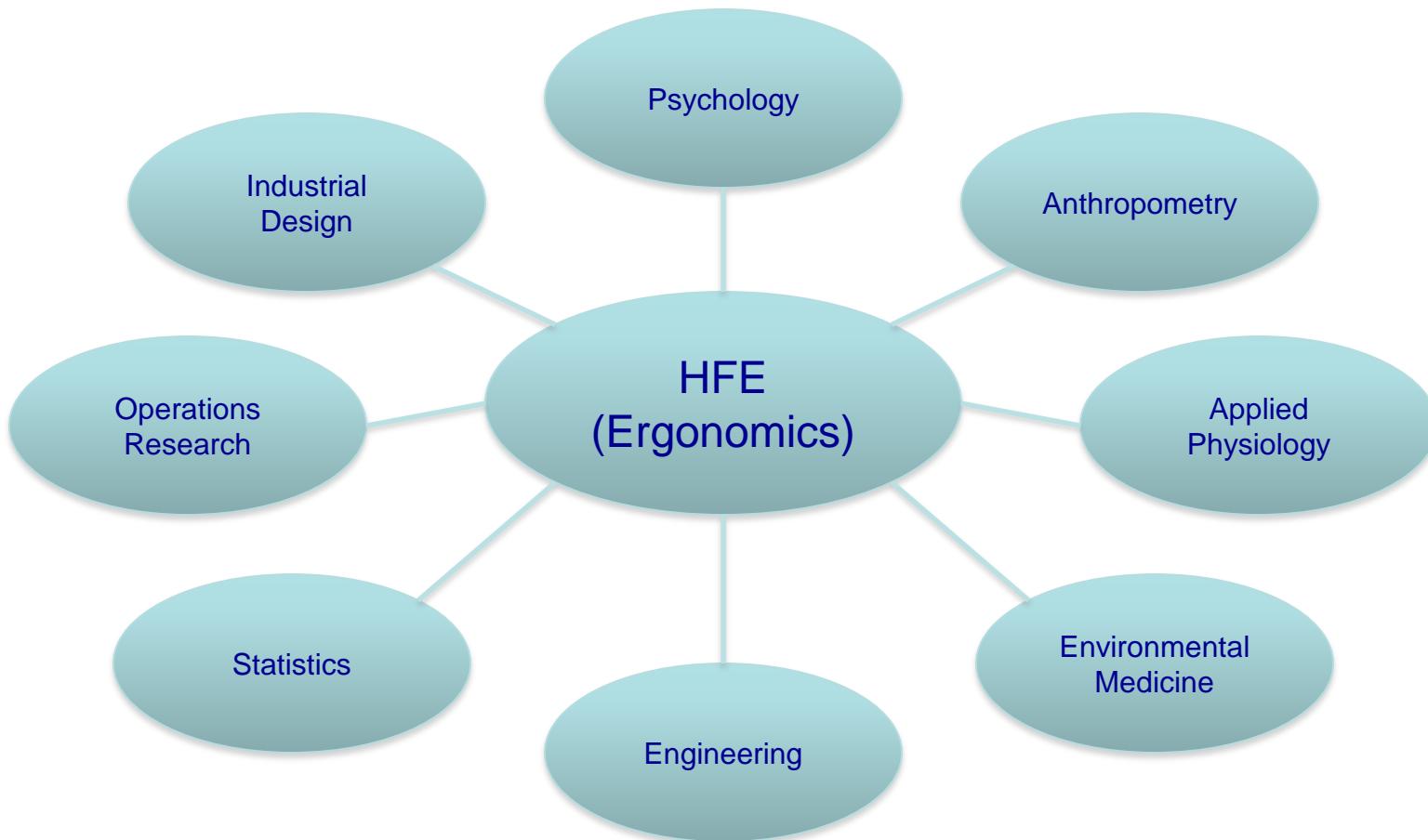
*Designers must facilitate **Human** performance...*

*...by creating a **System** that responds effectively...*

*...to the challenges of the **Environment***



Technical Disciplines Contributing to HFE



Source: Human Factors in Systems Engineering (A. Chapanis, 1996)

Human Physical Characteristics

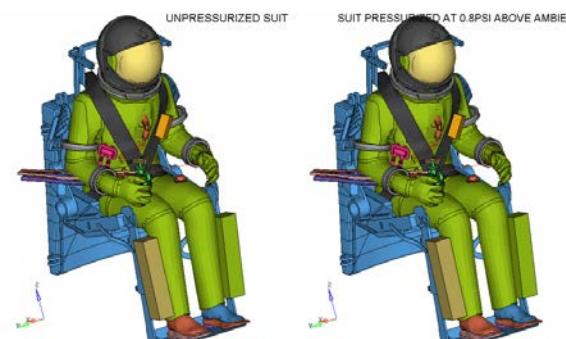
- There are no design drawings for people (Chapanis, 1996) but there are ways to quantify the human physical capabilities and limitations...

- Anthropometry: science of human dimensions
 - Biomechanics: force/torque capabilities of humans
 - Other machinery of the body
 - Nervous system
 - Respiratory and circulatory system
 - Metabolic system



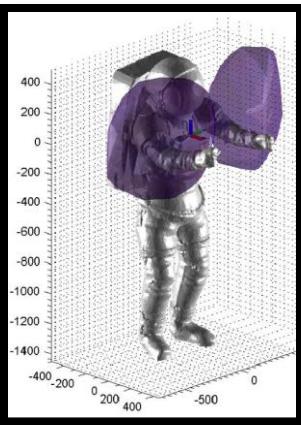
- We can provide reasonable estimates of working limits to human variability for effective interactions with the environment

- Help specify design limits to accommodate majority of the users
 - Facilitate safe, effective, efficient and comfortable work environment
 - Permissible *health* exposure limits
 - Noise
 - Vibration/ acceleration
 - Temperature/ humidity
 - Illumination

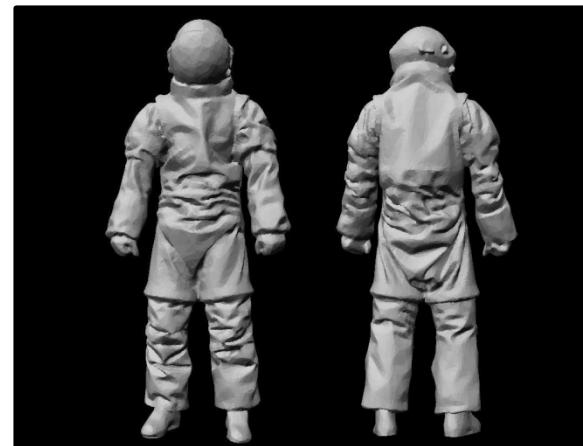


Human Physical Characteristics (cont'd)

The collection and maintenance of a consolidated anthropometric database of the crew population provides data required for analysis of accommodation for Exploration suits, seats, vehicles, and other hardware.



Benchmark current and future prototype suits through range of motion testing and task performance data (pressurized, unpressurized, 0-G, 1-G environments)

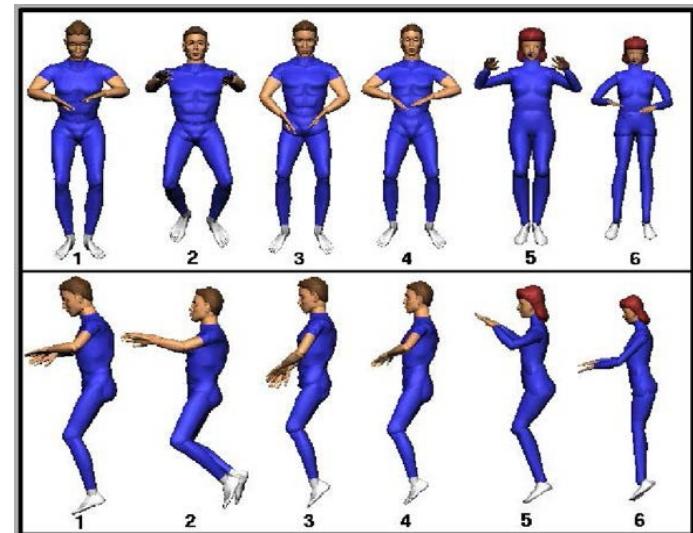


- Easy scanning of crew and/or hardware
- Captures a large amount of data
- Short data collection time (10-12 seconds per scan)
- Measurements can be easily verified
- Scanned images saved for future use

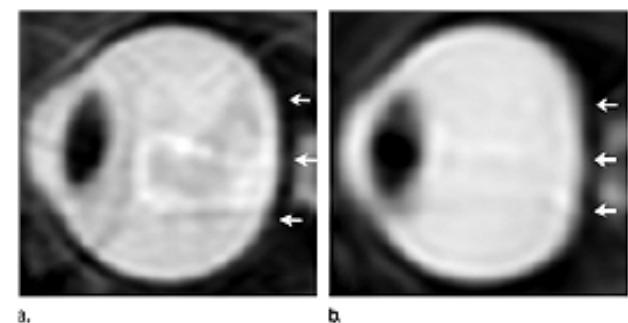


Human Physical Characteristics (cont'd)

- Known physiological responses to microgravity
 - Space adaptation sickness
 - Fluid shifts
 - Neuro-Vestibular Effects – “Disconnect” between vestibular system and visual system
 - Cardiovascular deconditioning
 - Spinal elongation
 - Bone loss
 - Muscle atrophy
 - Ocular effects – visual acuity decrement

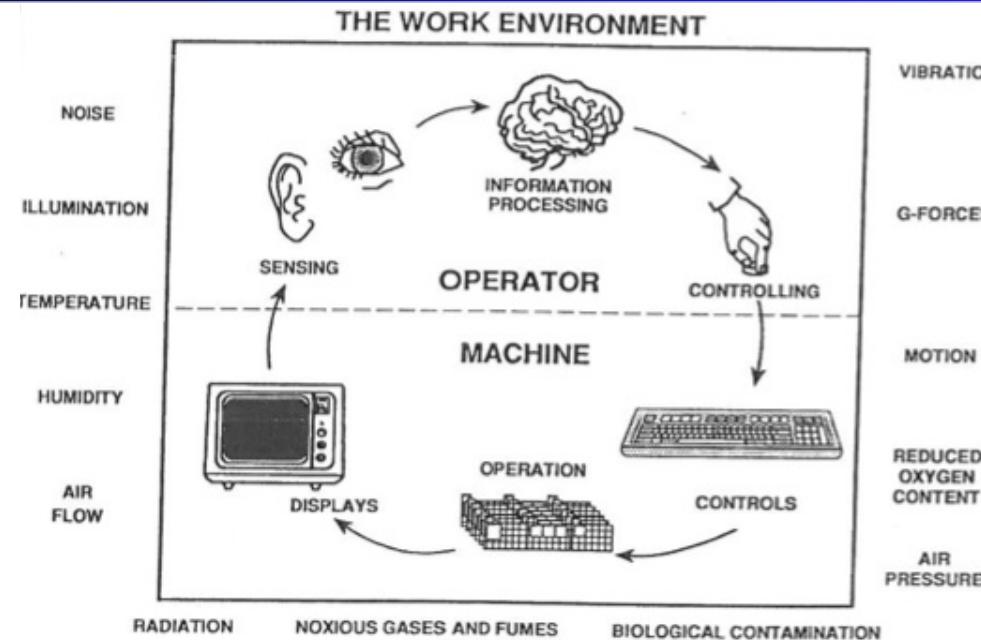


Neutral Body Posture



Sagittal oblique T2-weighted MRI. (A) Image of left eye before long-term exposure to microgravity. (B) The same eye after long-term exposure to microgravity. Note loss of convexity of the posterior scleral margin (arrows). Images courtesy Radiological Society of North America.

Human Mental Characteristics



Source: Human Factors in Systems Engineering (A. Chapanis, 1996)

- Human system
 - Senses – attending, sensing (sight, hearing, tasting, smelling, touch pressure, position/movement, acceleration/vibration)
 - Memory – remembering
 - Decision making
 - Learning – motor learning and skill acquisition
 - Responding
- We can establish thresholds for auditory/visual/tactile performance and design effective user interfaces

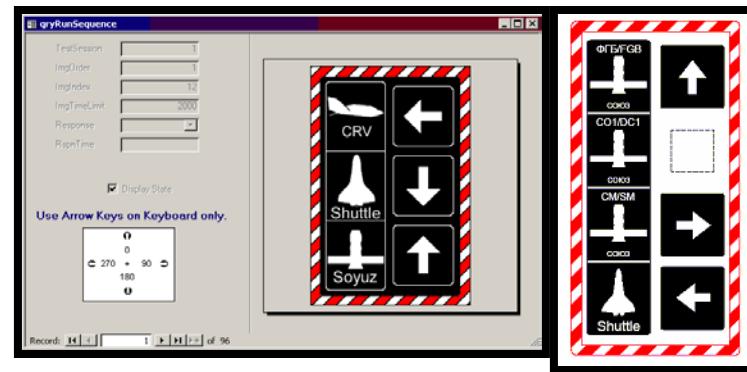
International Space Station

Human Factors Research

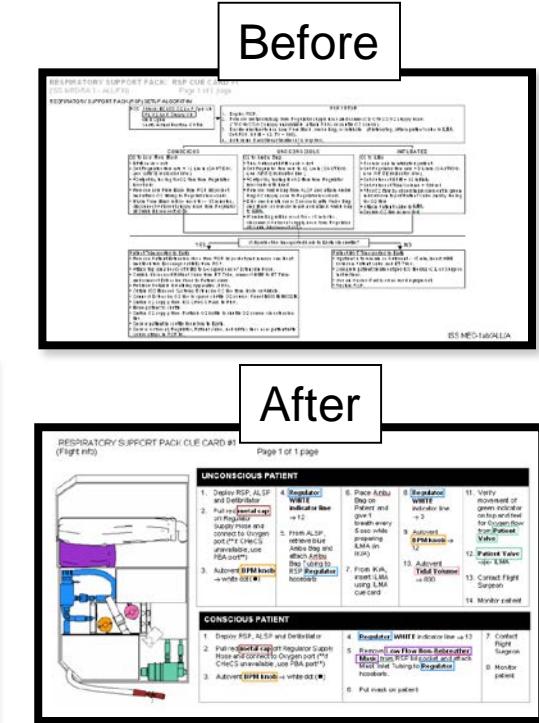
Human factors evaluations improve the implementation of hardware, placard, and procedure designs for ISS emergency operations.



Guidelines based on eye tracking studies contributed to the ISS medical pack redesign.



Evaluation of a multi-egress placard led to modified placards placed near ISS hatch entrances, indicating the direction to the emergency escape vehicle.



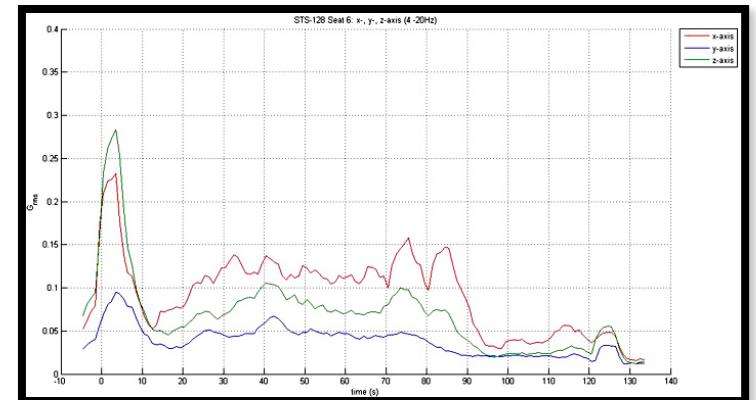
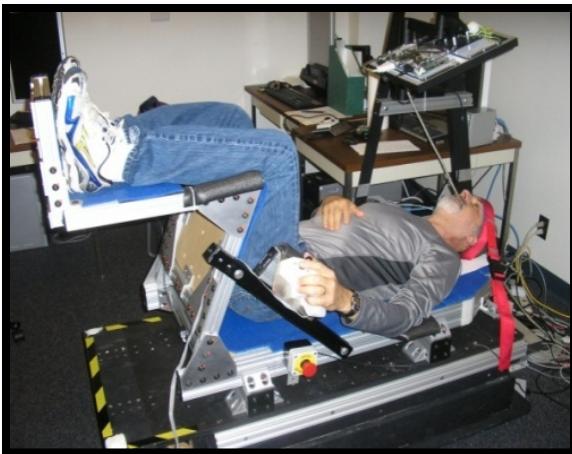
Through iterative design and evaluation, a time savings of **3 minutes** was achieved for the redesigned Respiratory Support Pack (RSP) cue card procedure.

Performance under Vibration

Evaluations of readability and cursor control operations under vibration lead to the development of vibration requirements for optimal crew performance.



The placards used during flight are shown at post-MECO for STS-119 (left) and pre-flight for STS-128 (right).



Vibration profile from STS-128.

Cursor control device being tested in vibration chair.



HFE Methods

HFE Methods

- Basic versus applied research
 - Basic research to characterize the human capabilities and underlying mechanisms
 - Applied research to develop requirements, guidelines, specifications, processes and design solution as well as countermeasures and mitigations
- Selected methods:
 - Operational/ activity analysis
 - Functional flow/ analysis
 - Task analysis
 - Fault tree analysis
 - Timeline/ link analysis
 - Simulation/ modeling
 - Human-in-the-Loop Tests (including controlled experiments)
 - Usability and workload assessment
 - Structured interviews, debriefs and questionnaires

HFE Methods: Example

Net Habitable Volume (NHV) for Space Exploration Vehicles



*Additional examples provided as part of the Supplementary Slides.



- *Volume driving* task analysis
 - Task volume calculations based on historical data and mock-up measurements
- Computational modeling for visualizing physical dimensions
- HITL mock-up evaluations for capturing operational experience of crew members (for Orion)
- Applied research projects
 - ISS habitability assessment
 - 3-D space utilization to quantify the use of volume in microgravity
 - Computational modeling to determine the NHV requirements based on the design reference missions



NHV –Task Analysis

Volume driving task list excerpt:

CREW TASK			NOMINAL/CONTINGENCY	TASK DURATION	TASK FREQUENCY	PRIVACY	REQUIRES MIN / NO RECONFIG OF SPACE? (Dedicated)	POTENTIAL CONCURRENCES	POTENTIAL ADJACENCIES
ID	Main Task	Description							
1	Exercise	-Whole Body Aerobic -Whole Body Resistive	Nominal	Hours	Per Day	Semi-Private	Yes	-Recreation -Crew Health/Medical (e.g. Monitoring) -Whole Body Hygiene -Waste Collection and Management -Stowage	-Crew Health/Medical (e.g. Monitoring) -Whole Body Hygiene -Waste Collection and Management -Stowage

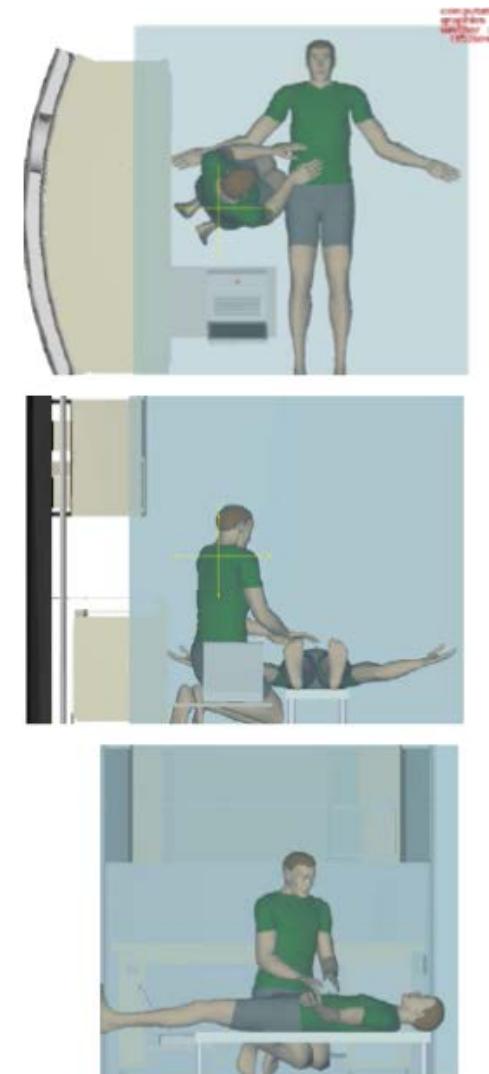
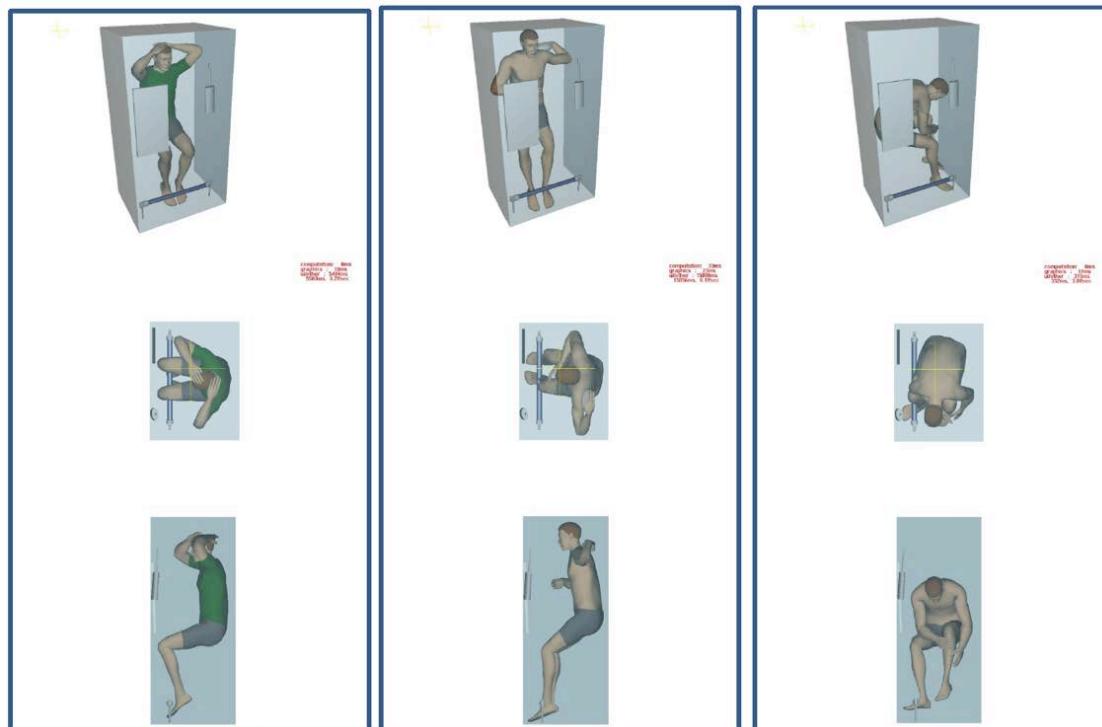
EXAMPLE VOLUMES

TASK/FUNCTIONAL AREA VOLUME					ADDT'L ANCILLARY VOL			ADDITIONAL NOTES		
Source	No. Of Crew	Foot print (ft or ft ²)	Height (ft)	Volume (ft ³)	HW/Sys	Point-of-Use Stow	Trans-lation			
Heritage	1	5.31	2.89	7.61	116.78	Included	Excluded	Excluded	Exercise in ISS Zvezda Service Module	
Human Integration Design Handbook	1	7.78	4.04	6.89	216.56	Excluded	Excluded	Excluded	Body volume for operating Treadmill with Vibration Isolation System (TVIS) (HIDH Table 8.2-1).	
	1	4.69	4.04	3.18	60.25	Included	Excluded	Excluded	Body volume for operating Cycle Ergometer with Vibration Isolation System (CEVIS) (HIDH Table 8.2-1)	
American Bureau of Shipping (ABS) Guide for Crew Habitability	1	20.00		6.50	130.00	Included	Excluded	Excluded	Volume estimates reference ABS Guide for Crew Habitability on Ships (p.108). Size given is for one physical fitness station. ABS requires stations to permit aerobic, flexibility and strength training capabilities.	
Other	1	4.30	3.30	7.30	103.59	6.7	Excluded	Excluded	Volume estimates reference CEV-T-70024 HSIR Rev D, based on anthro dimensions for max standing stature and max sitting height while using rower/cycle ergometer (no arms overhead). HW Vol estimates reference Table 18-5 "Mass and Volume Factors for Crew Accommodations" in "Human Spaceflight Mission Analysis and Design"	

Computational Modeling for Visualization of Physical Dimensions

- Task volume calculations were based on:
 - Historical data
 - Mock-up measurements

Task Volume Estimates for Partial Hygiene
Functional Volume (in shaded blue): 1.64m^3 (H= 1.95m; L=1.05m; W=.80m)



NHV – Orion HITL Evaluations

Early and iterative HITL evaluations:

- Reveal design and integration problems, and opportunities for cost efficient improvements
- Extend the design process beyond 2D modeling to include interactive 3D human task performance
- Spearhead verification planning



Vehicle Ingress and Egress

Net Habitable Volume Configuration

Focused HITL evaluations leading to design improvements

- Display & Controls
- Seat design, ingress and egress
- Crew vehicle egress & survival operations
- Stowage
- Habitability & environmental systems
- Net Habitable Volume
- Docking camera design and operations
- Hatches & hatch height
- Windows



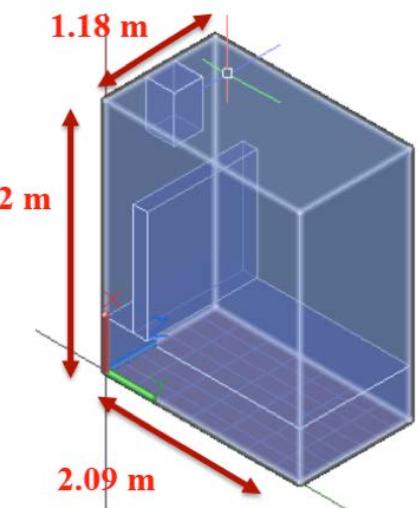
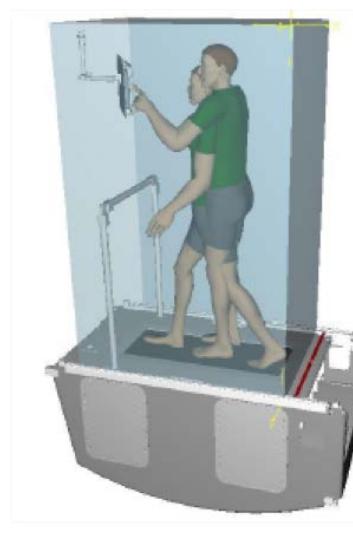
Displays and Controls



Seat Design

NHV Computational Modeling

- Research Objective: Develop a constraint-driven, optimization-based model that can be used to estimate and evaluate spacecraft/habitat volume.
- Current Status: Development started with two use case:
 - Examines two use case tasks: treadmill exercise and medical procedure
 - Uses approximated hardware dimensions



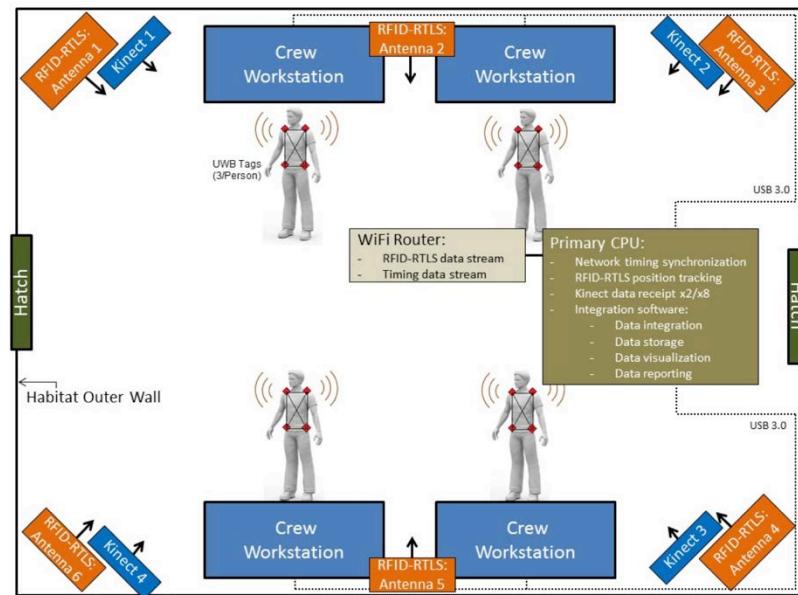
Habitability Assessment on ISS

- **Research Objective:**
 - ▶ Characterize the current state of ISS habitability, i.e., how crewmembers currently utilize the volume on ISS
 - ▶ Specific focus areas include: Private personal areas, group activities, suit donning and doffing, crew health and medical procedures, stowage
 - ▶ Determine how the ISS data relates to long-duration spacecraft/ habitat design
- ▶ **Current Status:** Data collection in progress



Automated 3-D Space Utilization Data Collection

- Research Objective: Develop an automated methodology for quantifying 3-D space utilization.
 - The number of crew present in each area of the vehicle at any given time
 - The quantity of time crew spend at each workstation in the performance of tasks
 - The physical orientation of crew while utilizing the provided volume
 - Frequent or common translation paths and traffic flow patterns within the volume
 - Operational flow/volume required for mission tasks by single or multiple crew
- Current Status: Integration of the hardware technologies (3D RFID-RTLS and Microsoft Kinect 3D volumetric scanning tools) and initial development of software interfaces has begun.

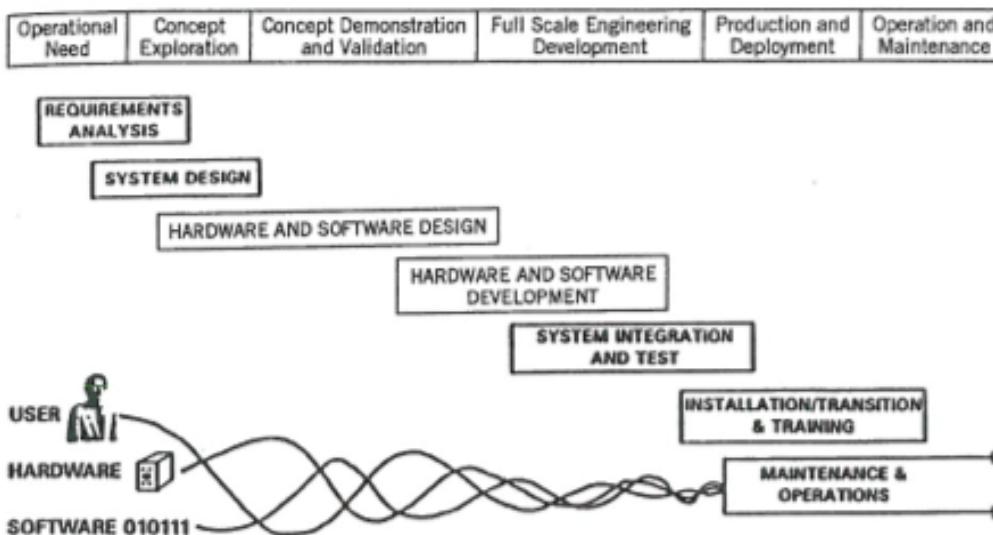




HFE in Systems Engineering

HFE in Systems Engineering

- Processes to implement HFE
 - Human Systems Integration (HSI)
 - User-Centered Design (Human-Centered Design)



Systems Engineering Process. Source: Human Factors in Systems Engineering (A. Chapanis, 1996)



Human-Systems Integration (HSI)

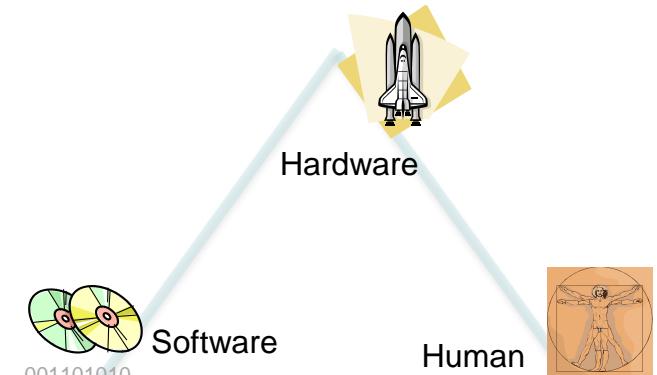
What is HSI?...

- INCOSE's Definition:

"Human Systems Integration (HSI):"

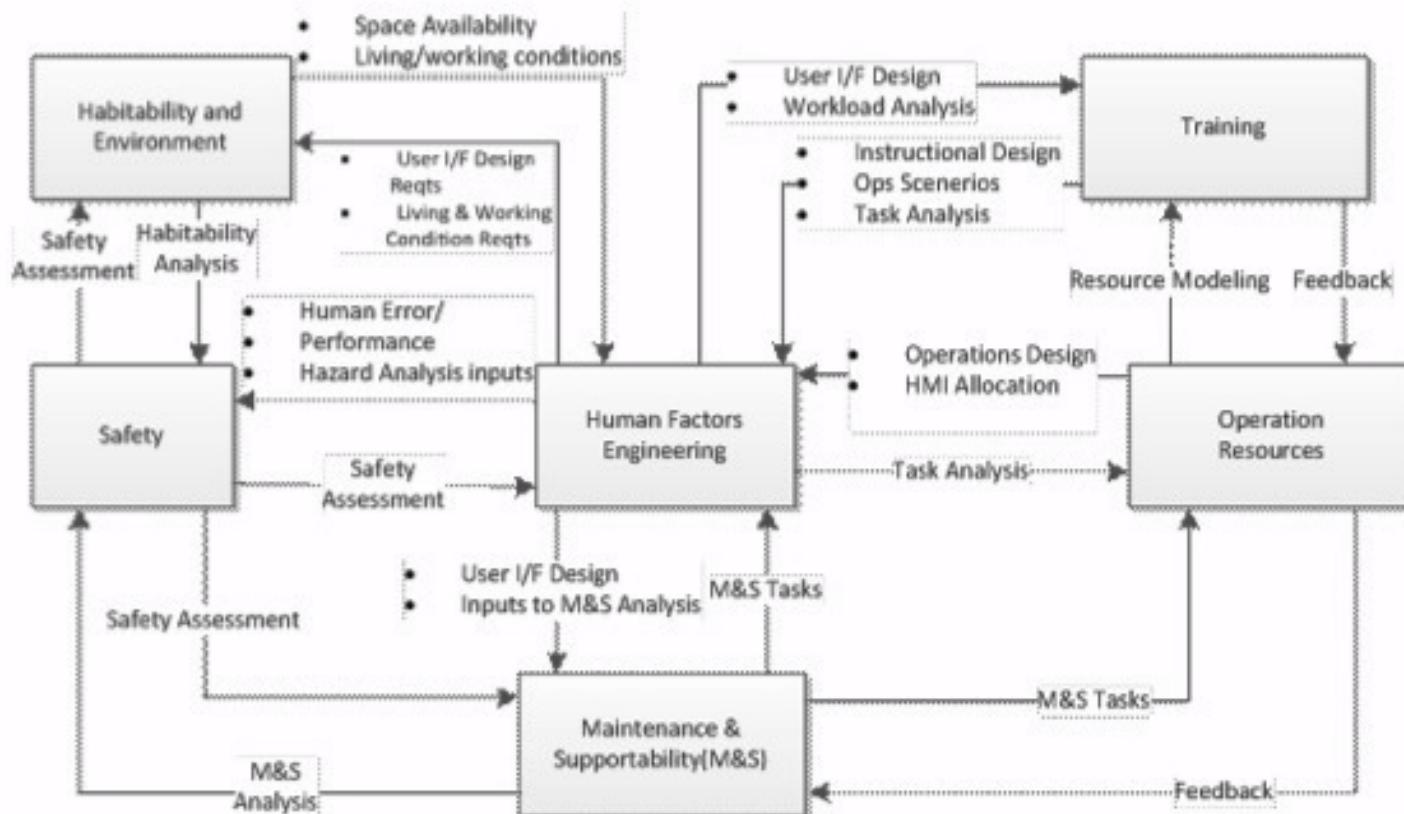
The interdisciplinary technical and management process(es) for integrating human considerations within and across all system elements.

HSI is an essential enabler to systems engineering practice.”



Source: International Council on Systems Engineering (INCOSE) definition of “HSI” as determined by their Human Systems Integration Working Group, April 2, 2007.

HFE Interactions with Other HSI Domains



Source: Human Systems Integration (HSI Practitioner's Guide, NASA/SP-2015-3709 (NASA, November 2015)



User-Centered Design

- What is User-Centered Design?
 - Iterative approach starting early in the design process and continuing through the life cycle of the program/project.
 - Systems are designed to fit user population with the goal of:
 - Minimizing potential for human errors
 - Reducing training time
 - Improving safety, productivity, and comfort
- How can the user population be accommodated through a Systems Engineering approach to design?
 - **Equipment Design** based on anthropometry
 - **Task Design** to fit capabilities/limitations of users
 - **Environmental Design** provides work environment which limits stress (i.e., temperature, lighting, sound)
 - **Training** provides appropriate skills commensurate with task demands



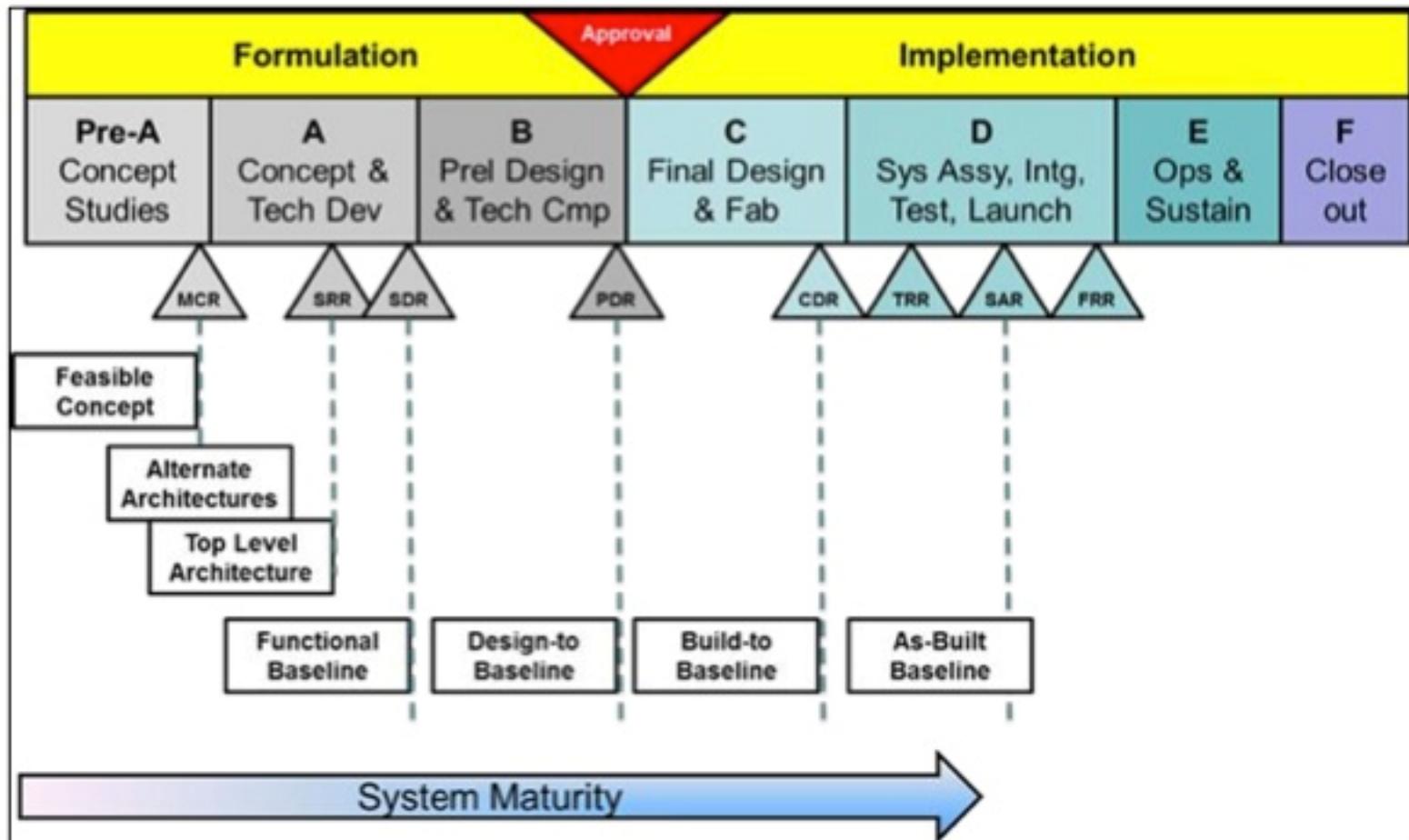
In summary...

- HSI applies and integrates multiple domains including HFE, and it employs UCD/ HCD approach for system design.
- Majority of the time, HFE practitioner is the lead and/or core HSI team member that enables the implementation of this overall approach.



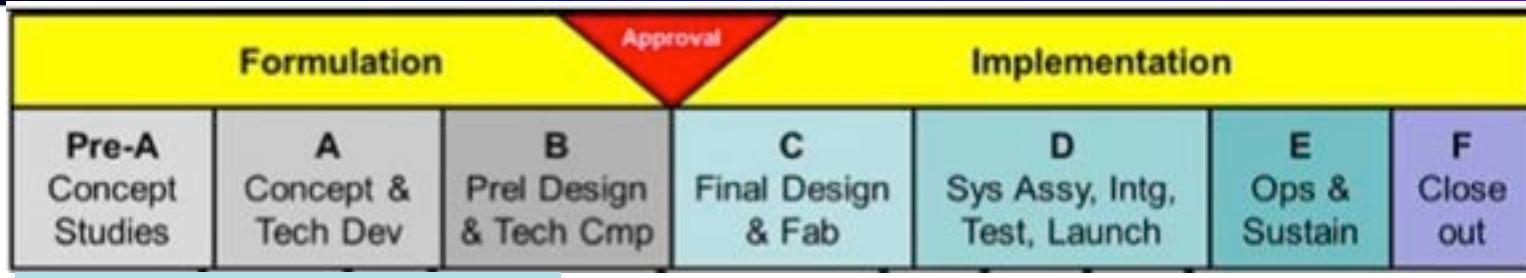
HFE SE-related Activities and Work Products

NASA's Acquisition Life Cycle Phases



Source: Human Systems Integration (HSI Practitioner's Guide, NASA/SP-2015-3709 (NASA, November 2015)

Example HFE SE-Related Work Products



Requirements Definition/
Technical Solution

Product Realization (Design, Evaluate and
Transition to Operations)

Capturing
Lessons Learned

- Function allocation
- Task Analysis
- Concept prototyping
- Human-in-the-Loop (HITL)
- Concept of operations
- HFE/HSI requirements
- HFE/HSI requirements
 - Assessment
 - Verification & validation
- HITL tests
- Preparation for operations
 - Training plan and materials
 - Simulations
 - Ground processing HFE
- Effective database infrastructure
- In-flight crew comments
- Postflight crew debriefs
- Standard objective measures of human performance
 - Effectiveness and efficiency of user interface and interaction design



What if human-system interaction/ interface
goes wrong?...



Examples of Human Factors Related Issues in Complex Space Systems THEN and NOW

- Gemini 9 – Gene Cernan (1966)
 - "Every time I'd push or turn a valve, it would turn my entire body in zero gravity. I had nothing to hold on to. And we take for granted gravity, because we can do that kind of work with ease if something is holding our feet to the ground. Nothing was holding me anywhere."
 - His face visor fogged up due to profuse sweating – he'd rub his nose on the faceplate to create a peephole.
 - Once in the vehicle, his hands were so swollen that when he pulled off the suit's gloves, some of his skin came with them.
- On International Space Station (ISS)
 - Designers are still struggling with how to prevent nail discoloration/damage from wearing EVA gloves.
 - Researchers are looking at spinal growth during extended microgravity to determine considerations for adjustable suit sizing.
 - In 2004, a 2-week drop in vehicle pressure that could have resulted in evacuation was found to be due to crew unknowingly using a hose as a hand-hold when they needed to stabilize their position in microgravity.

It is critical to consider the human-system interaction.

NASA-Mir Incidents and Close Calls



Morgan, C. (2001) "Shuttle-MIR: The United States and Russia Share History's Highest Stage" NASA-SP-4225, NASA Johnson Space Center, Houston, TX.

Near Collision 1997: "A near collision with a resupply cargo ship during a manual docking system test"

Accident 1997: Progress collided with the Mir Spektr module, depressurized it, and severely damaged solar arrays. Spektr was isolated, cables through hatchway impeded hatch closing.

"What [operator] was seeing on his screen was an image that didn't change in size very fast... He couldn't determine accurately from the image that the speed was too high."

Most Recent Commercial Spaceflight Accident

- Virgin Galactic's suborbital space plane SpaceShipTwo was destroyed in a tragic accident during a test flight on Friday (Oct. 31, 2014). The crash left pilot seriously injured and co-pilot fatally injured.
- Probable Cause:
 - *Scaled Composites'* failure to consider and protect against the possibility that a single human error could result in a catastrophic hazard to the SpaceShipTwo vehicle.
 - Resulted in copilot's premature unlocking of the feather system as a result of time pressure and vibration and loads that he had not recently experienced, which led to uncommanded feather extension and the subsequent aerodynamic overload and in-flight breakup of the vehicle.



"Space is hard and today was a rough day"

Virgin Galactic CEO George Whitesides, Oct. 31, 2014

Most Recent Commercial Spaceflight Accident

- Based on the craft's telemetry and cockpit during the launch, National Transportation Safety Board (NTSB) investigation* focused on the ***crew actions*** and ***flight crew-vehicle interface***.
- The following stressors contributing to the Co-pilots error:
 - Memorization of tasks – data card not referenced
 - Time pressure – complete tasks within 26 sec
 - Operational environment – no recent experience with vibe and loads
 - Lack of consideration for human error
 - No safeguards in design to prevent error
 - No warning in manuals/procedures
 - Sim training did not replicate operational environment
 - Hazard analysis did not consider pilot-induced hazards



* http://www.ntsb.gov/news/events/Pages/2015_spaceship2_BMG.aspx

Most Recent Commercial Spaceflight Accident (cont'd)

- NTSB Recommendations:
 - Develop **human factors** guidance for operators to use throughout the design and operation of a crewed vehicle.
 - Improve the experimental permit application process
 - Implement a voluntary database of **lessons learned** from commercial space mishap investigation.



Source: Dr. K. Wilson's Presentation at the HRP Investigator's Workshop (February, 2016)

Our challenge is identifying these HFE/ HSI issues and resolving them before they result in a catastrophic accident!



But the good news is...

- We are learning from these accidents/ incidents
- We have been systematically collecting *operational* lessons learned during the human spaceflights
 - Crew debriefs
 - Crew reports from past spaceflight programs like Appollo, Mir, Shuttle
- We have HFE system managers/ subject matter experts actively supporting the current programs like ISS, Orion and Commercial Crew Programs
- We have Human Research Program (HRP) based upon a risk mitigation framework (<http://humanresearchroadmap.nasa.gov/explore/>)
 - Goal: Provide crew health and performance *countermeasures, knowledge, technologies, and tools* to enable safe, reliable and productive human space flight
 - Check out the 5 SHFE risks, gaps and tasks for more information

Future HFE/ HSI Challenges for Successful Space Exploration

“New technology does not remove human error. It changes it.”
-- Dekker (2006)

- Spaceflight Operations are **changing**
 - New vehicles with “glass cockpits”
 - Crew access to more information and new technologies that are unproven in space
 - Crew operating with time delays and decreased ground support
 - New robotic exploration agents, beyond robotic arms and Earth-controlled rovers
 - Highly autonomous systems, beyond current experience with limited maturation
 - Planetary exploration in the 21st Century
- New **standards/ guidelines and design solutions** for HFE/HSI are required for future exploration missions.



SpaceX Dragon Vehicle



Planetary Surface Operations

Source: The Field Guide to Understanding Human Error (S. Dekker, 2006)



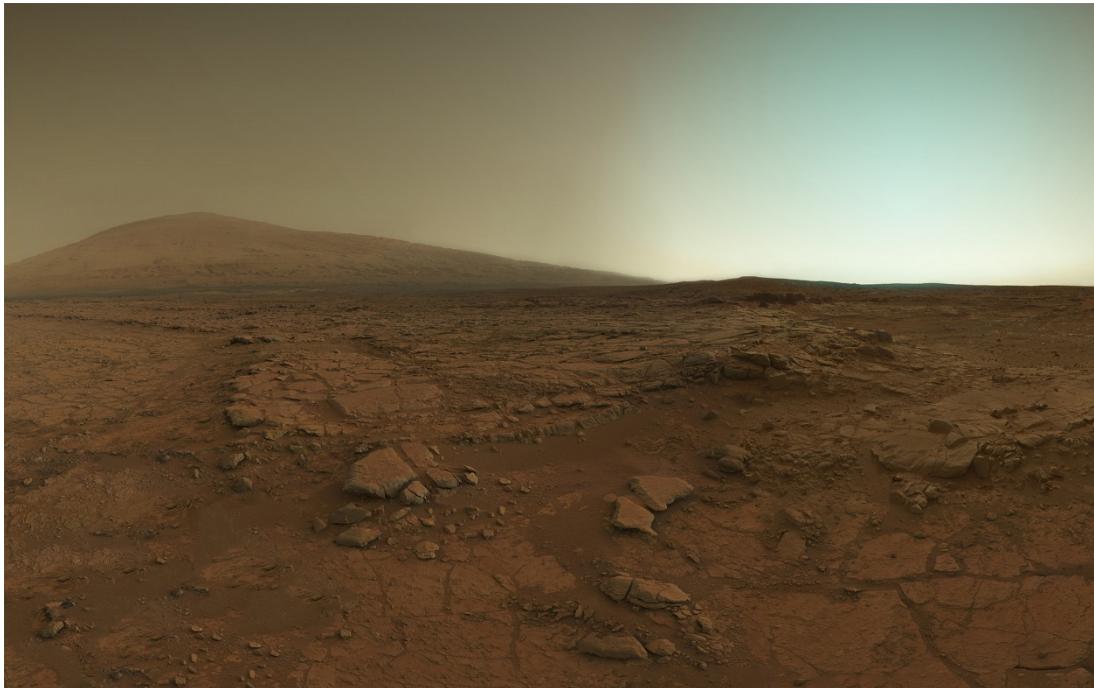
Closing Notes...

- Consider Human as one of the systems, not an add-on after the design is complete.
- Develop HSI implementation plan early and execute it throughout the acquisition life cycle.
 - Make sure to identify key HSI metrics to assess success
- Use UCD/HCD – iterative process considering the users' needs and requirements

Selected References:

- NASA-STD-3001 Space Flight Human-System Standard Vol 1 (Crew Health) and Vol 2 (Human Factors, Habitability & Environmental Health)
- NASA/SP-2010-3407 Human Integration Design Handbook (HIDH)
- NASA/SP-2015-3709 Human Systems Integration (HSI) Practitioner's Guide
- Mil-Std-1472F DOD Design Criteria Standard (Human Engineering)

Thank You!



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Supplementary Information



Human Factors Specialty Areas

- Industrial engineering
 - Human Factors
 - Human engineering/ ergonomics
 - Anthropometry and biomechanics
 - Workstation design
- Psychology
 - Human factors
 - Engineering psychology
 - Human-computer interaction
 - Usability and user interface
 - Aviation psychology
 - Experimental psychology



Fun Facts about Space Exploration

Space Videos/Animation

Exploration Mission 1: <https://www.youtube.com/watch?v=Mo8IkHM8fGE>

Astronaut's Point of View of NASA's Orion Spacecraft Re-entry during its 1st flight test: <https://www.youtube.com/watch?v=MtWzuZ6WZ8E>

Life onboard ISS:

<https://www.youtube.com/watch?v=FMRn-NMzetM&feature=youtu.be>

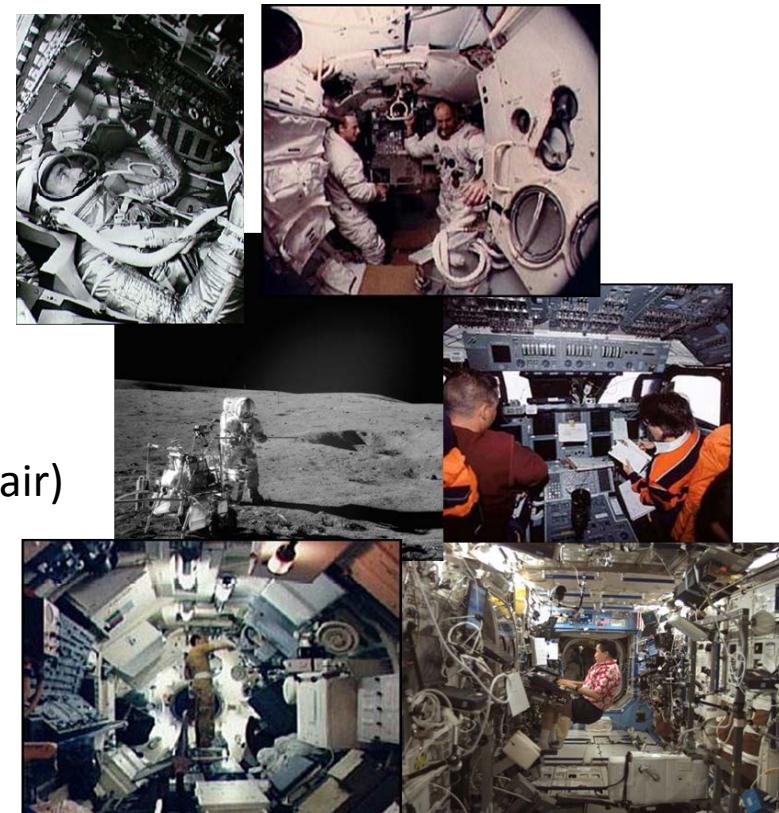
Tweets from ISS

- “Still adjusting to zero g. Just flipped a bag upside down to dump out the contents.”
- “I read before bed. It still doesn’t feel right to hold a weightless book. My mind doesn’t like it one bit.”
- “Losing a tool is devastating up here. Finding it 20 hours later floating 3 modules away is euphoria!”
- “My feet are finally starting to wake up. They’re becoming useful appendages in microgravity.”
- “Just changed a light bulb. FYI – only one astronaut (and a small ground team) required.”
- “Zero G living rocks! Moving 1600lb MELFI freezer with minimal effort.”
- “Node1 -> Lab -> Columbus module. Two handrails touched. Gaining new level of flying ability.”
- “Week 4 complete. Life is almost normal. View still insane. Floating still a novelty. Science is the best part of the day.”

Space Environment Considerations

- **External Environment**

- Gravity (high – ascent/entry, micro/partial – LEO, lunar, planetary)
- Temperature Extremes
- Radiation
- Vacuum
- Micro-Meteor/Orbital Debris
- Lighting
- Electrical charge



- **Internal Environment**

- Isolation and confinement
- Noise and Vibration
- Closed loop life support environment (H_2O & air)
- Waste production/elimination/recycling

- **Operations**

- Launch/Ascent/Entry
- Extra-Vehicular Activity (EVA)
- Robotics
- Payload activities/medical experiments
- Crew schedule/workload

SHFE Research Domains

Habitability (HAB)

- How much habitable volume is needed for a long-duration vehicle or habitat to ensure adequate health, safety and performance? How do we determine the best layout?



Human-Computer Interaction (HCI)

- How do we design displays and controls for long-duration, autonomous missions? How much information will autonomous crew need, and in what format?



Human-Robotic/Automation Interaction (HARI)

- How do we design interfaces so that humans and automation/robots can work together effectively?



Training (TRAIN)

- How do we design training for long-duration, autonomous missions? What can be trained pre-flight and what requires Just-in-Time training?



Task Design (TASK)

- How do we design crew tasks and procedures so that usability and workload are appropriate during long-duration missions?



HFE Activities at NASA – Additional Examples

Orion Displays and Controls

Prototyping & Evaluation

Human engineering improves the design of displays and controls for Orion by establishing display format standards and applying a rigorous human factors process.



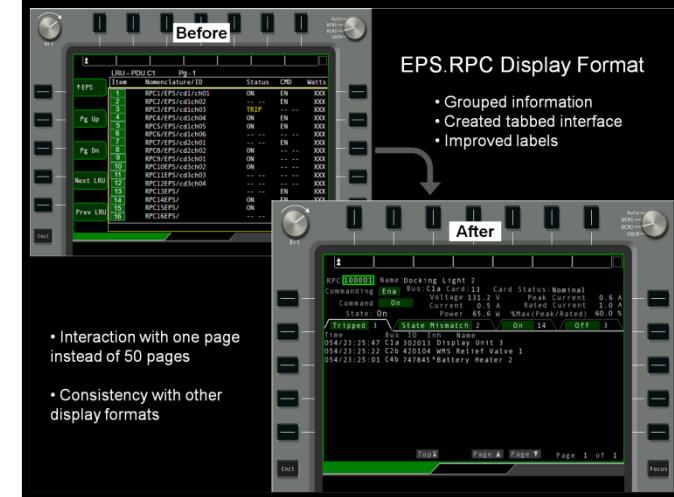
Evaluations of controls in reduced gravity and under pressurization



Generation of the cursor control device, from a clay model to the final product, including ergonomic and functional testing



Iterative design of abort control



Display format before and after human factors input and evaluation

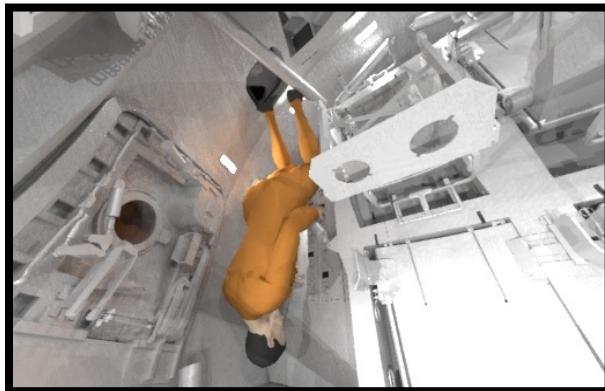


Human factors input resulted in increased in-line and cross-cockpit viewability, improved reach and access to controls, better labeling and use of LEDs, and improved organization and placement of controls.

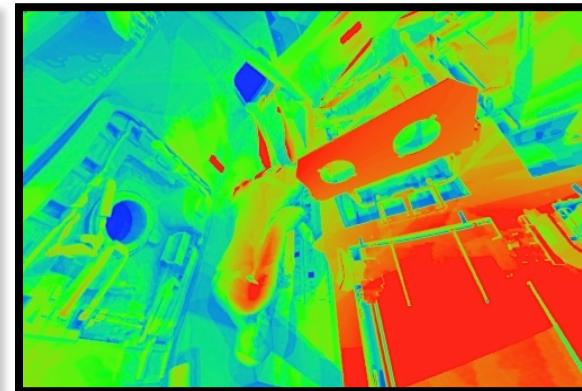
Orion Interior Lighting Analysis

CAD model-based lighting simulation allows the Orion lighting design engineers to interactively evaluate effects of changes in light fixtures, avoiding the need to create high-fidelity mockups.

Lighting analysis shows that window refraction limits the panel area where sunlight strikes.



Model View



Color-coded Illumination Plot

	Without Glass	With Glass
Model predicts front window sunlight on displays and control panel		
Model predicts side window sunlight on displays and control panel		

Evaluation of visual and auditory methods of information display aids system designers at Glenn Research Center in the selection of technology for the presentation of EVA procedures.



Human factors heuristic and usability evaluations optimize the electronic cuff and voice recognition systems (e.g., terminology to match the task).



Evaluation of simulated geology tasks using a Head-Mounted Display (HMD) and voice recognition system provides design recommendations for viewing EVA procedures.

EVA Umbilical Connector Design

Usability evaluations, early and often, influence progression of the Constellation EVA umbilical connector design, location, and orientation on the suit.



Chest location was eliminated due to occupant protection and Orion operability issues.



Initial connector design with small blue handle.



Human factors input and evaluation led to change in handle shape.



Usability evaluations determined the optimal connector location, orientation, and design on the right thigh.

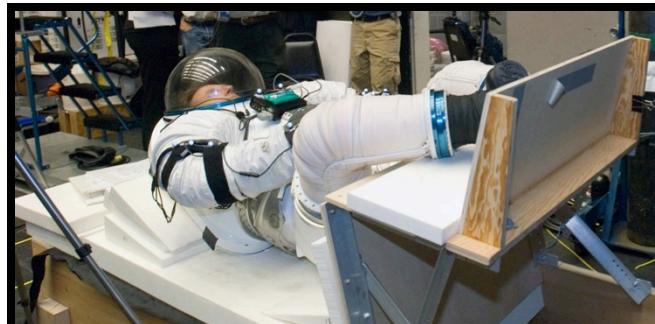
EVA Integrated Tests

Human factors and EVA personnel evaluate suited operations to improve human performance, maneuverability, interferences, and efficiency for the next-generation suits for Orion and Lunar Surface Systems.

1-g Evaluations



Orion emergency pad egress



Evaluation of launch seat comfort in planetary EVA suit

Reduced Gravity Evaluations



Evaluation of Orion EVA installed handrails and hatch operations, using Human Research Program-developed Maneuverability Assessment Scale and anthropometry data.



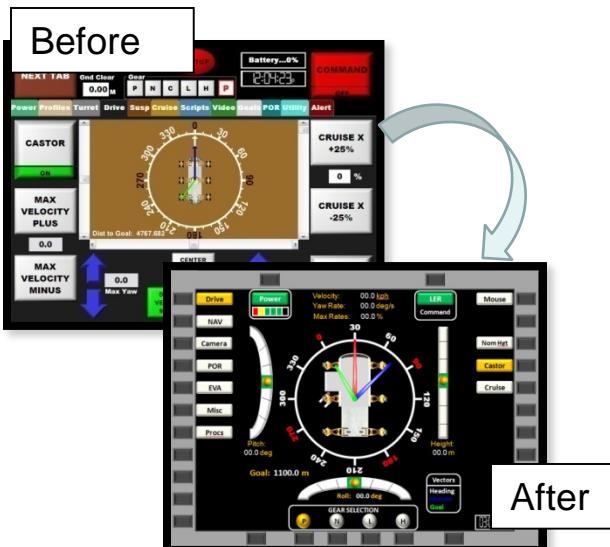
Lunar 10km walkback test



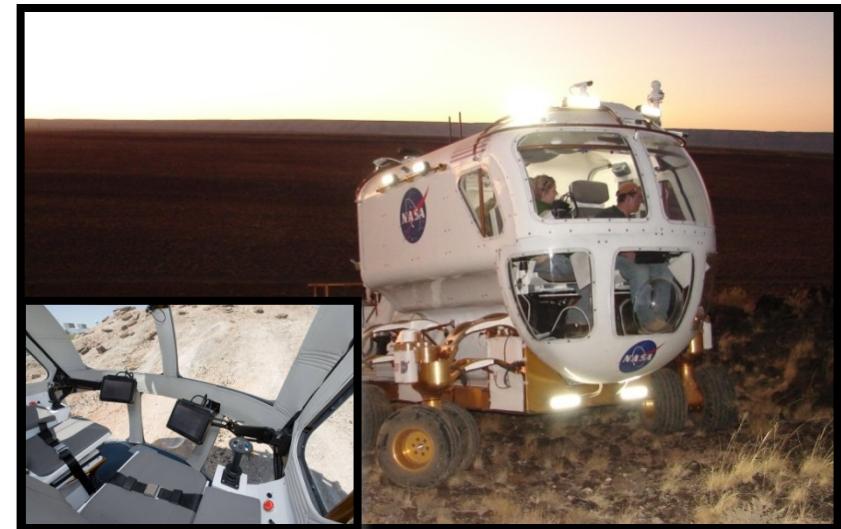
Human performance assessment at different center of gravity locations

Surface Exploration Vehicle (SEV)

Applying human factors principles and evaluation of critical tasks to display design and window placement improves usability and situational awareness.



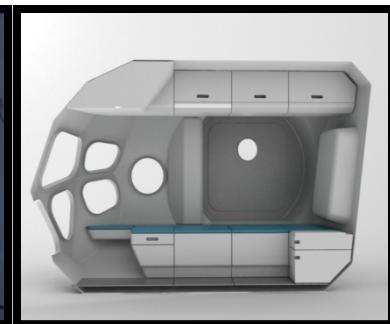
Display design before and after human factors input and evaluation.



Placement of displays.



Testing of different window configurations in the Reconfigurable Orbital Cockpit (ROC) facility followed by a CAD of the recommended design.



ISS Flight Crew Integration (FCI) Crew Comments Database

The Flight Crew Integration (FCI) ISS Life Sciences Crew Comments Database is the most complete archive of ISS crew debrief data in existence.

FCI ISS Life Sciences Crew Comments Database

FCTISS Life Sciences Crew Comments Database

View All Site Content

Documents

- Tools
- Review and Edit Page
- Source Documents
- Form Library
- Report Library
- FCI Data Connections
- Work Files
- Documentation

Lists

- Calendar
- Tasks

Pictures

- Photo Gallery

Discussions

- Team Discussion

Sites

People and Groups

Recycle Bin

A SharePoint site used by the ISS Flight Crew Integration (FCI) team to manage and trend ISS Expedition crew data in support of exploration activities.

Lessons Learned Documents

Type	Title	File Size
Word	E19/20 Lessons Learned	102 KB
Word	E18/19 Lessons Learned	111 KB
Word	E18 Lessons Learned	109 KB
Word	E16/17 & E17/18 Lessons Learned	245 KB
Word	E16 Lessons Learned	132 KB
Word	E15 Lessons Learned	135 KB
Word	E14 & E14/15 Lessons Learned	207 KB
Word	E13/14 Lessons Learned	119 KB
Word	E13 Lessons Learned	123 KB
Word	E12 Lessons Learned	131 KB

Presentations

Type	Title
Word	Roadshow_Presentation_FCI Db
Word	OpsHub PRM
Word	FCI Roadshow Presentation 2010 PPT
Word	FCI Roadshow Presentation PDF

Announcements

Expedition 22/23 Debrief data was added to the database on 8/20/10 by Schuh, Susan V. (JSC-SF)[WYLE INTEG, SCI. & ENG.] 9/3/2010 9:22 AM

E23/24 Debriefs by Bagian, Krista Rose, (JSC-SF)[WYLE LABS] 9/3/2010 9:21 AM

The E23/24 US crewmember will return in late September (9/23) onboard 22S. Debriefs will begin in mid-October.

Approved Data Summaries

- Habitable Volume
- Waste and Hygiene
- Labeling
- Robotics
- Procedures

FCI ISS Life Sciences Crew Comments Database SharePoint Site

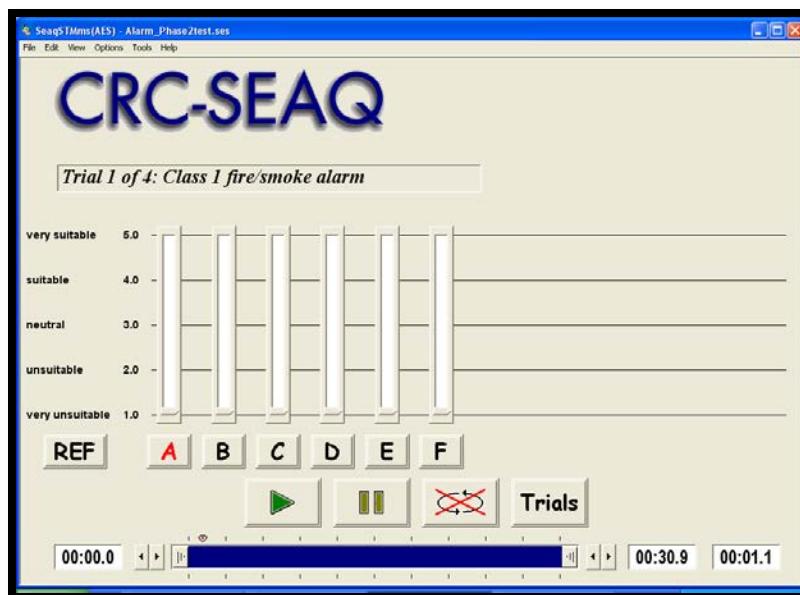


This secure SQL repository allows the systematic search of over 35,000 crew comments from ISS post flight crew debriefs from Expedition 1 to the present.

The database is a valuable resource that allows the creation of products and use of data to support design & development of vehicles, hardware, requirements, procedures, processes, and research protocols for current & future spaceflight programs.

Auditory and Visual Displays

Empirical results from Human Factors research drive generation and evolution of requirements, yielding improved safety and productivity.



Evaluations of different auditory alarms result in design requirements and standards for future space vehicles.

elapsed time 34
upper limit 21
analog input close
total pressure left

With long labels, word values take longer to process than numeric values.

Cooling unit 69
Nominal force 79
Vent 11
Fan 34

Search times are faster when using a combination of short and long labels.

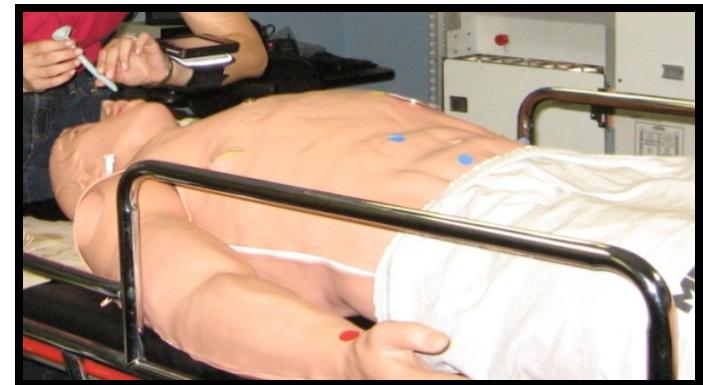
Horizontal
90° Left
90° Right
M
a
r
q
u
e
e

Horizontal text preferred. If vertical text must be used, avoid marquee style

Evaluations involving visual search times and errors for labels and values as a function of different types of alignment, orientation, and formats provide information for design and standards development.

Medical Just-in-Time Training

Evaluations of display technology for simulated just-in-time procedures using a human patient simulator provide new insights into use of electronic procedures during medical operations.



Head Mounted Display (HMD) and wrist-mounted PDA were evaluated with a paper cue card.

Wrist-mounting the PDA is a viable hands-free option for just-in-time procedures.

Alternative methods for scrolling on the smaller display screens are needed to facilitate hands-free commanding.